

## 4 Axis Implementation of the Active Feedback Mirror System for the IR Beamline 1.4.3

Wayne R. McKinney<sup>1</sup>, Michael C. Martin<sup>1</sup>, Mike Chin<sup>2</sup>, Greg Portmann<sup>2</sup>,  
Miklos E. Melczer<sup>3</sup>, and James A. Watson<sup>3</sup>

<sup>1</sup>Advanced Light Source Division, <sup>2</sup>Engineering Division,

Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, California 94720, USA

<sup>3</sup>Lawrence Livermore National Laboratory, 7000 East Ave., Livermore, CA 94550-9234

### INTRODUCTION

After extensive passive noise re-mediation Beamline 1.4.3 still had low frequency noise spikes on the IR spectrum, and broadband noise over the whole spectrum.<sup>1,4</sup> To address low frequency acoustic noise, technology adapted from a design used at Lawrence Livermore Laboratory was implemented--two dual axis Physik Instrumente tip/tilt PZT mirror holders with 1 mm thick mirrors and Hamamatsu position sensitive detectors. Feedback was provided by dichroic beamsplitters from Spectra-Tech and custom circuitry by LBL. The first tip/tilt mirror was placed just after the diamond window in the switchyard. The detector for the first tip tilt, the first beamsplitter, and the second tip/tilt mirror were placed in a spool piece on the microscope table (shown in inset of Figure 1). The two systems allow the active system to pin the beam at two positions to approximately one micron thus stabilizing the beam in both position and angle. The system as originally proposed was described in a 1999 ALS Compendium Abstract.<sup>5</sup> We present here data from the complete 4 axis implementation of the system. We show in Figure 1 a drawing from the 1999 Abstract which outlines the system.

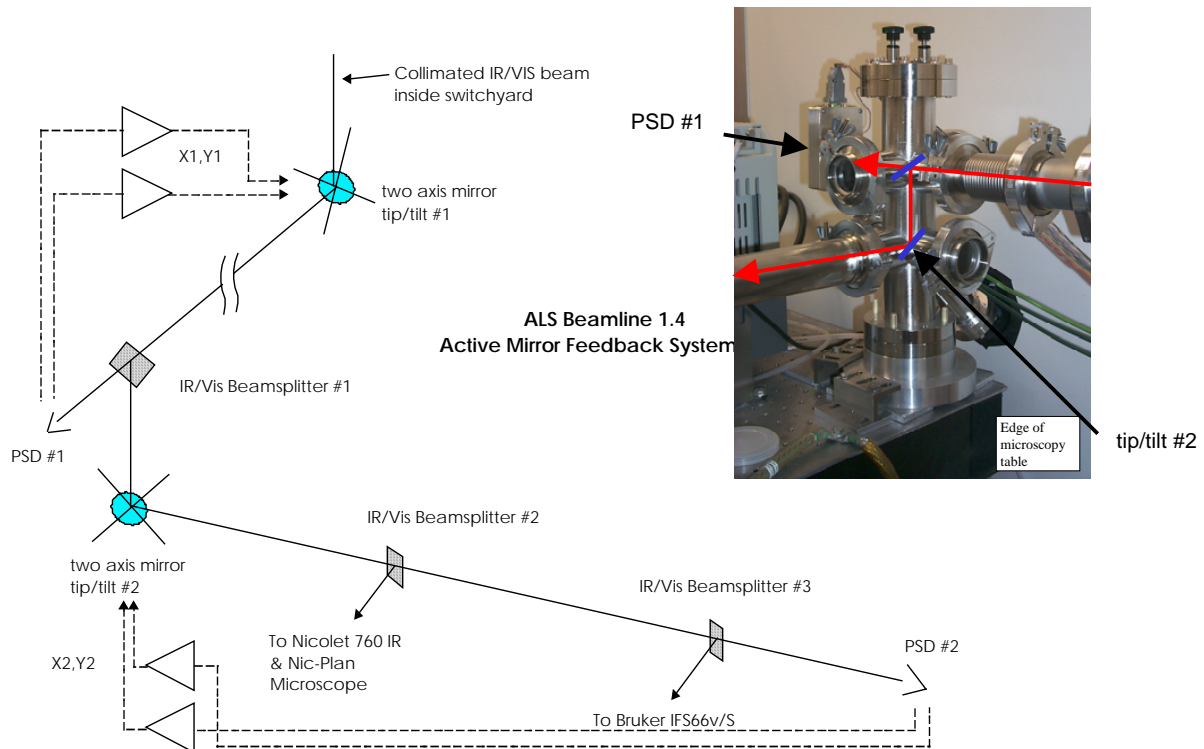


Figure 1. Schematic of 4-axis feedback system implemented on Beamline 1.4. Inset shows photograph of spool piece housing the first beamsplitter, PSD #1, and tip/tilt mirror #2.

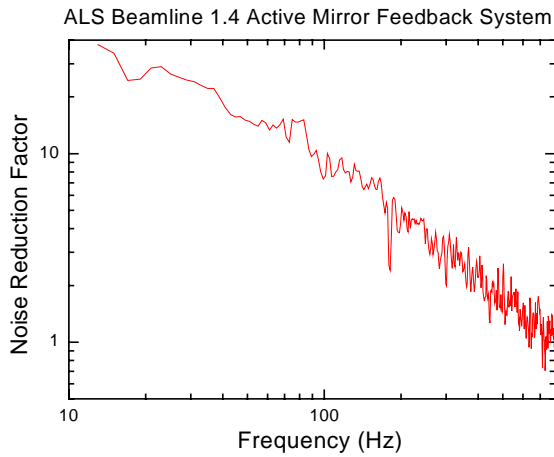


Figure 2. Noise reduction factor observed on one of the four channels.

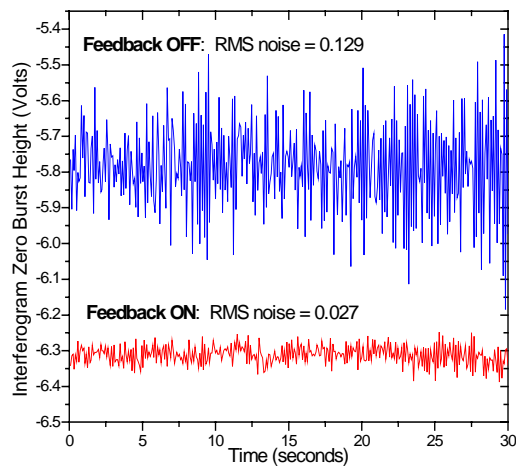


Figure 3. Variation of the interferogram zero burst height as a function of time with the feedback system on and off.

The system was implemented essentially as previously described. Figure 2 at the left shows the ratio of the power spectra of the error signals from one of the four channels. This gives an indication of the amount of stabilization achieved as a function of frequency. The system reduced by approximately an order of magnitude the noise error signals on the position sensitive detectors from ALS storage ring girder vibrational modes and the 80 Hz mode suspected to be vibration of the M2 mirror. Figure 3 on the left shows a time series of maxima of the FTIR interferogram zero burst with and without the active mirrors energized. An approximately 5 fold decrease in the rms variation in the zero burst height was achieved. Figure 4 below shows the open loop response in the horizontal plane using ALS beam on the mirrors. The top trace is amplitude response, with first resonance between 2 and 3 kHz. The bottom trace is the phase response (due to sign inversion, -180 Deg is 0 phase lag). Our original intention to have gain up past the first mechanical resonance with a notch in the response to remove oscillation was not achieved.

The system greatly reduces low frequency noise caused by the angular motion of the synchrotron beam. Interferogram jitter is greatly reduced. We did not see however a decrease in the broad spectrum noise in the FTIR spectra as we had previously seen as we eliminated larger noise sources by non-active methods. To further test that

the system does not alias single frequency noise over the whole spectrum we introduced a single frequency spike by driving the piezos with an oscillator. This frequency (100Hz) was the only extra noise seen during the test. Our preliminary conclusion is that we have reduced the noise by both passive and active methods to such a level that only linear effects in the interferometric spectral calculation process are important. It appears that the synchrotron beam actually moves in angle at all frequencies from ~DC to ~20 kHz with an rms amplitude of ~1 micro-radian.

One somewhat unexpected benefit of the active stabilization system is that the diffraction limited spot at the sample stage in the IR microscope stays put as the ALS beam drifts or comes back up at a different place after a refill or retune of the machine. The beam is brought back to the exact same place in the focal plane since the positions of the position sensitive detectors do not change. Of course if a beamline mirror after the servo loop is adjusted, this alignment is lost. We have found that using a silicon sample with a 16 micron disk of titanium supplied by Jim Underwood of the CXRO we can locate the exact position of the beam in the microscope field, and maintain it for many days. This feature has proved very worthwhile to our users using the full spatial

resolution of the diffraction limited spot. The necessity to take maps of a larger area because the exact location of the spot is not known is completely eliminated.

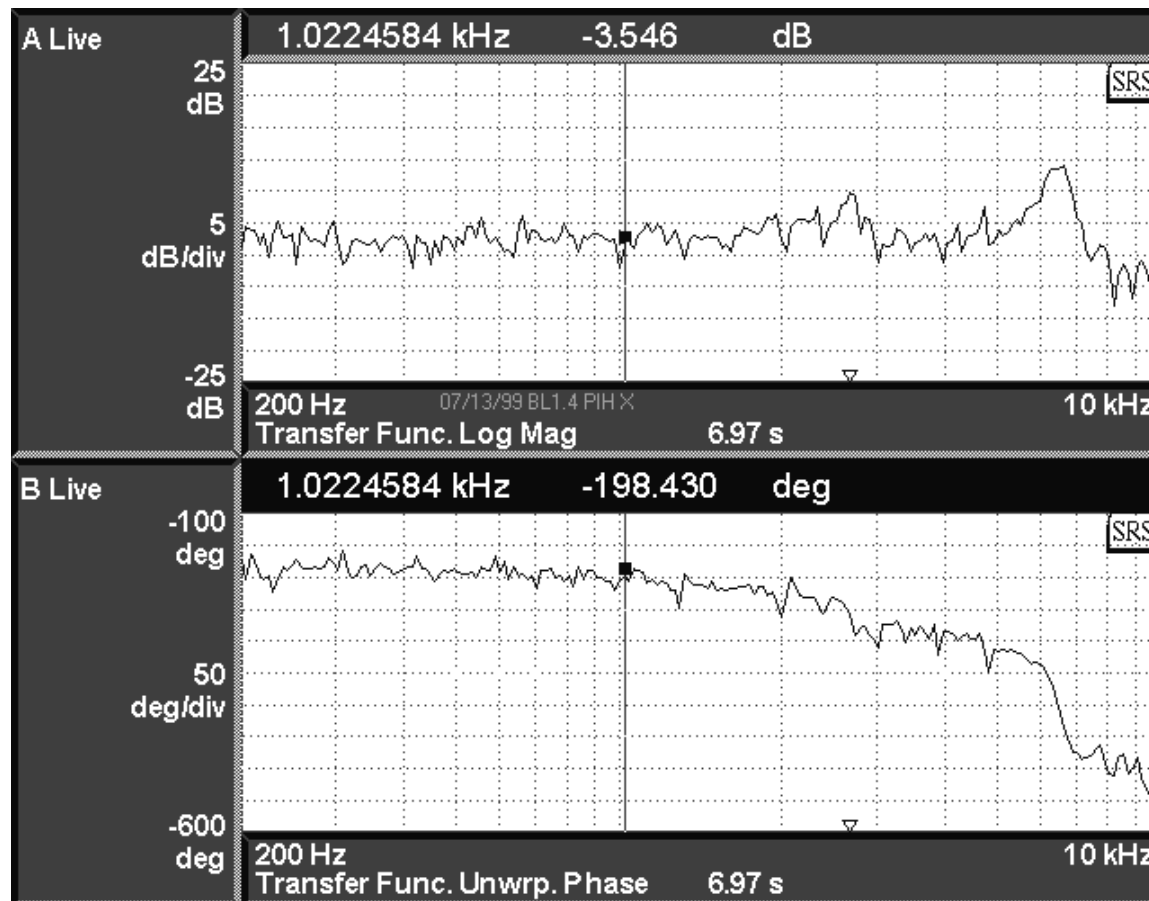


Figure 4. Open loop response of the feedback system in the horizontal plane using the ALS beam.

## REFERENCES

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This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Science Division, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Principal investigator: Wayne R. McKinney, Advanced Light Source Division, Ernest Orlando Lawrence Berkeley National Laboratory. Email: WRMckinney@lbl.gov. Telephone: 510-486-4395.